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U.S.-JAPAN COMPETITION IN SEMICONDUCTORS: AMERICAN MAKERS RETHINK STRATEGIES

Summary

Silicon Valley executives have warned since the late 1970s that the United States risked losing world leadership in the critical semiconductor field to Japan unless Washington helped reverse the odds (see JEI Report No. 30A, August 12, 1983). Experts now say the question no longer is which country's industry will be the technological and market leader; instead, it is whether American manufacturers of semiconductors for outside sale will survive and how. Merchant manufacturers and industry analysts have mapped out a long list of survival strategies, but one of the few points of agreement is that U.S. suppliers must expand their limited sales in Japan using last year's trade pact as the springboard. Most controversial is the move by major merchant makers to form partnerships with their Japanese rivals in areas ranging from development work to production.

Changing Competitive Environment

Boom-and-bust business conditions have always been a fact of life for U.S. semiconductor manufacturers selling on the open market, but the battering the merchant industry has taken in the mid-1980s goes beyond the normal cyclical contraction. Thirty months after orders went on the skids, producers still see no signs that a strong upswing in demand for integrated circuits and discrete devices is in the works, either at home or abroad. By itself, the length of this dry spell sets the current slump apart from earlier ones. Yet both Silicon Valley executives and Reagan administration policymakers are convinced that the causes of the domestic industry's problems run far deeper than weak

demand. They argue that fundamental changes have occurred in the world semiconductor market -- changes that threaten the continued existence of the major merchant makers as independents regardless of what happens to demand.

To no one's surprise, Japan's semiconductor companies are the villains in the scripts circulating around the merchant industry and Washington. For starters, Japanese makers, after steadily chipping away at the once-dominant world market share of U.S. suppliers, now control at least as much of the global business as their American competitors, according to leading American market research firms.

To make matters worse, say industry and government officials, Japanese competitors have decimated the ranks of domestic producers of DRAMs (dynamic random access memories) and wreaked havoc with the operations of U.S. suppliers of EPROMs (erasable programmable read-only memories). While commodity memory products account for only 15 percent or so of the semiconductor market, they have traditionally provided the profits to finance ever-increasing research and development costs and capital spending requirements in these and other semiconductor product lines. Moreover, the production processes mastered in turning out high-volume memory chips can be transferred to almost every device in a company's lineup. In short, analysts say, the forced retreat of merchant makers from commodity memories represents a double blow to the competitive position of the U.S. semiconductor industry.

American producers have also discovered that there are few havens from Japanese competition. In the early 1980s U.S. leadership in cutting-edge microprocessors and the peripheral chips used with them was believed to be immune to challenge; now, however, Japanese manufacturers are taking aim at this market. The same goes for bipolar logic circuits and other products like static RAMs. More recently, merchant producers that thought they had finally found shelter in the market for semicustom chips -- partially finished standard-design circuits that are tailored to each customer's needs -- have had another rude awakening: Japanese suppliers are also trying to occupy this niche.

Semiconductor Industry Association leaders and administration trade officials have a straightforward explanation for the success of Japan's assault on the world leadership role of American manufacturers, arguing that the structure of both its industry and its market gives Japanese challengers unfair advantages. Merchant makers' main Japanese competitors are huge, vertically integrated companies that generate a relatively small part of their revenues from sales of ICs and discrete devices. This structure, domestic critics charge, allows Japanese producers to sell commodity chips like DRAMs and EPROMs at prices that do not cover production costs. It also provides deep pockets to finance the development work and capital spending that are critical to continued international competitiveness. At the same time, industry and government representatives add, American semiconductor makers are unable to stake out anything more than a foothold in the Japanese market -- now estimated to rival the U.S. market in size -- because the biggest users of semiconductors are also the largest producers.

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The semiconductor trade agreement negotiators for the United States and Japan initialed July 30, 1986 after nine months of intense bargaining was an unprecedented attempt to address these twin U.S. complaints. The pact commits Tokyo to insure that Japanese suppliers price DRAMs and EPROMs at fair prices in both the United States and third markets and take steps to expand sales opportunities in Japan for foreign semiconductor producers (see JEI Report No. 28B, August 1, 1986). Administration officials are the first to acknowledge that these measures deal only with the symptoms of the problem. They argue, however, that if the agreement is fully implemented, it will go a long way toward neutralizing the structural advantages of Japanese semiconductor manufacturers.

Although questions of compliance have dogged the pricing part of the agreement almost from the start, the pact has brought belated price relief, particularly in the American market, to the two surviving merchant makers of DRAMs and to the larger group of domestic companies producing EPROMs. On the other hand, U.S. government and industry officials say they are still waiting for some evidence of the "steady" improvement in foreign access to the Japanese market that Tokyo promised.

Progress on this front has been slow. Yet Washington and Silicon Valley should have realized that the problems they had complained about for years would not disappear in nine months, even with Tokyo running interference. As Japanese officials have maintained all along, the government can promote a more open Japanese market but cannot guarantee increased U.S. sales in Japan. Responsibility for that development rests squarely with the private sector and -- as the American side concedes -- with U.S. semiconductor suppliers, which must demonstrate that they are committed to meeting the stiff requirements of Japanese buyers.

New Commitment to Japan

Merchant semiconductor manufacturers admit that their past performance in Japan makes it more difficult to win new business from demanding Japanese customers since in the all-important areas of price, quality, delivery and service, American suppliers have not always measured up to the local competition. But company spokesmen quickly add that the record of the last two years or so indicates a new U.S. commitment to the Japanese market. They point out that during a period of retrenchment in other parts of their operations, many of the 16 makers with Japanese sales subsidiaries (see Table 1) have expanded their marketing, support and/or quality-control staffs. Moreover, companies that have design centers have added engineers and technicians and in some cases installed new computer-aided engineering equipment, convinced that a strong in-country design capability is the key to expanded sales, particularly in the fast-growing Japanese market for ASICs (application-specific integrated circuits) or custom chips and semicustom devices like gate arrays and standard cells.

While labeling these moves steps in the right direction, Japanese market watchers insist that American semiconductor makers will never be more than marginal players in Japan unless they build manufacturing facilities there. Only four companies now have Japanese plants in operation (see Table 2) and just two have integrated facilities -- U.S. industry leader Texas Instruments

Inc., which ranks among the top 10 producers in Japan, and Motorola, Inc., the second-biggest American IC maker. Most of the other major merchant producers have considered establishing a Japanese production presence in recent years but have concluded that their current or near-term sales in Japan could not justify the $150 million or so it now costs to build a wafer fabrication plant there. Executives of a few of these companies have even questioned whether TI and Motorola are generating an adequate return on their Japanese investments since Texas Instruments Japan Ltd.'s 1985 semiconductor sales were $319 million (using a yearend exchange rate of Y200=$1.00) while Nippon Motorola Ltd.'s came to $32 million.

Proponents of a U.S. manufacturing presence in Japan reject this often-heard line of argument, saying that sales may never be large enough to justify a plant without building the plant first. One company that has decided to break this vicious circle is LSI Logic Corp. Later this year the Milpitas, California maker's Japanese subsidiary will open up a fabrication facility for silicon wafers and ASICs that is being financed in part by Kawasaki Steel Corp. Said the head of LSI Logic's local operation at the time the plant was announced, "This is the only way we can convince the Japanese user that we are serious" about serving the market.

Motorola is also making another effort to break the vicious circle. After announcing plans in July 1985 to build a second integrated production facility in Japan, Motorola unveiled a sweeping five-year agreement with Toshiba Corp. in late November 1986 that includes construction of an equally owned plant outside of Tokyo. Both companies will provide product technology for the factory, which is scheduled to come onstream in the first part of 1988. Japan's number-three semiconductor producer will contribute designs for the production of current and future generations of DRAMs and SRAMs, while Motorola will transfer designs for a broad line of microprocessors. But in a move widely applauded in the United States, Motorola has conditioned the transfer of its technology on increases in its semiconductor sales in Japan.

Several other merchant semiconductor manufacturers believe they have found ways to increase their Japanese market presence without investing in a plant. Under an open-ended 1985 agreement, for example, Zilog, Inc. is supplying the wafers for its 8-bit MPUs, 8-bit single-chip microcomputers and related peripheral chips to semiconductor maker Rohm Co., Ltd., which assembles and tests the products and then distributes them under its own name in Japan. Adopting a slightly different approach, National Semiconductor Corp. has what is known in the semiconductor business as a foundry agreement with NMB Semiconductor Co., Ltd. The five-year pact signed in September 1986 calls for National Semiconductor to provide the design technology for a line of SRAMs to be manufactured by the Japanese company, with marketing, both in Japan and elsewhere, handled by the U.S. firm. The first products are scheduled to be produced this summer.

Strategic Alliances

Partnerships of any kind are a major departure from the traditional go-it-alone strategies of merchant semiconductor manufacturers, but tying up with Japanese competitors represents a radical change in corporate philosophies. Many U.S. industry analysts believe, however, that selective alliances

Table 2: U.S. Merchant Semiconductor Manufacturers With Japanese Production Facilities

Company	Location	Year Opened	Processes	Products	Comments
Texas Instruments Inc.	Hatogaya, Saitama	1968	Wafer fabrication, assembly and test	MOS logic products	Roughly four-fifths of the products Texas Instruments makes in Japan are sold there.
	Hiji, Oita	1973	Wafer fabrication, assembly and test	Bipolar logic and memory products	
	Miho, Ibaraki	1979	Wafer fabrication, assembly and test	MOS memory products	
Motorola, Inc.	Aizu, Fukushima	1980	Wafer fabrication, assembly and test	Bipolar and MOS logic products	Initially a joint venture with Toko, Inc., Motorola bought out its partner in 1982. The plant's assembly capacity was recently increased 50 percent.
Analog Devices, Inc.	Shiroyama, Kanagawa	1982	Assembly and test	Linear: digital-to-analog and analog-to-digital converters and related circuits	Wafers imported from U.S. and U.K. plants. Factory assembles about half of the linear circuits Analog Devices sells in Japan.
Fairchild Semiconductor Corp.	Isahaya, Nagasaki	1984	Assembly and test	Bipolar and MOS logic products	Wafers imported from the United States. Completed but unopened wafer fabrication facility recently put up for sale.
LSI Logic Corp. Kawasaki Steel Corp.	Tsukuba, Ibaraki	1987*	Wafer fabrication	Silicon wafers; ASIC products	The plant's output will be shipped to other LSI facilities for assembly and testing and then will be marketed by the company in Japan, the United States and other markets. Kawasaki is a minority partner.
Motorola, Inc. Toshiba Corp.	Izumi, Miyagi	1988*	Wafer fabrication, assembly and test	MOS memory and logic products	Each of the partners in the equally owned venture will get half of the plant's output. The factory will initially make Toshiba's memory chips, later adding Motorola's microprocessors to the lineup.

*Planned

Table 1: U.S. Merchant Semiconductor Manufacturers With Japanese Sales Subsidiaries

Parent	Subsidiary	Year Opened	Main Semiconductor Product Lines	Design Center	
				Year Opened	Products
Texas Instruments Inc.	Texas Instruments Japan Ltd.	1968	MOS memory; MOS logic; bipolar logic; bipolar memory	*	*
Motorola, Inc.	Nippon Motorola Ltd.	1968	MOS logic; MOS memory; bipolar logic; bipolar memory	n.a.	n.a.
Analog Devices, Inc.	Analog Devices K.K.	1969	Linear circuits; hybrid circuits	1982	Linear circuits
Fairchild Semiconductor Corp.	Nippon Fairchild K.K.	1972	Bipolar logic; MOS logic	1985	Gate arrays
National Semiconductor Corp.	National Semiconductor Japan Ltd.	1972	Linear circuits; bipolar logic; MOS logic; microprocessors, microcontrollers and peripheral circuits	1980	Linear circuits
Advanced Micro Devices, Inc.	Advanced Micro Devices K.K.	1974	Linear circuits; bipolar logic; microprocessors and peripheral circuits	1987**	Semicustom products
Signetics Corp.	Signetics Japan Ltd.	1975	Linear circuits; bipolar logic; microprocessors, microcontrollers and peripheral circuits	1981	Linear circuits; microprocessors and microcontrollers
Intel Corp.	Intel Japan K.K.	1976	Microprocessors, microcontrollers, systems and boards; SRAMs; EPROMs	1980	MOS logic and memory products
Monolithic Memories, Inc.	Monolithic Memories K.K.	1976	Bipolar logic	--	--
Zilog, Inc.	Zilog Japan K.K.	1977	Microprocessors, microcontrollers and peripheral circuits	--	--
LSI Logic Corp.	LSI Logic K.K.	1984	MOS logic	1984	ASICs
Linear Technology Corp.	Linear Technology K.K.	1985	Linear circuits	--	--
International Rectifier Corp.	International Rectifier Far East Ltd.	1986	Field-effect transistors; solid-state relays	--	--
VLSI Technology Inc.	VLSI Technology K.K.	1986	ASIC products	1986	ASICs
Integrated Device Technology Inc.	Integrated Device Technology K.K.	1987	SRAMs; MOS specialty memories; microprocessors; MOS logic	--	--
Standard Microsystems Corp.	Toyo Microsystems Corp.	1987	ASIC products	1987**	Standard cell products

*Texas Instruments has design centers in Tokyo, Osaka and Miho, which were opened between 1969 and 1979. These centers do work for both in-house use and customer-related requirements.

**Planned

with Japanese producers are key to the future health of American semiconductor makers. Given the fast pace at which technology is advancing and the soaring costs of R&D and production, they argue, no American company can now afford to design and manufacture the range of devices it once did.

A few U.S. suppliers have adopted this approach. In February 1986, for example, Advanced Micro Devices Inc. and Sony Corp. agreed to work together on the development of process technologies. Seven months earlier LSI Logic and Toshiba signed a four-year pact covering the joint development of a new generation of gate arrays, with the Japanese company in charge of developing the production technology and LSI Logic responsible for the computer-aided design software. In the product supply area, Mitsubishi Electric Corp. is providing CMOS (complementary metal-oxide semiconductor) logic devices to Texas Instruments in exchange for transistor-transistor logic circuits under an agreement disclosed late last year.

Partnerships such as these and the Motorola-Toshiba agreement are still unusual. Already, though, a small but growing number of experts, including some in the government, are worried that tie-ups between American and Japanese semiconductor manufacturers will exacerbate the U.S. merchant industry's problems, not help resolve them, since in their view the Japanese partner is more likely to benefit from the arrangement. Domestic companies reject this argument, pointing to the Motorola-Toshiba pact as proof that U.S. producers can work out deals that will be mutually beneficial. In any case, they add, the possibility that a foreign alliance might backfire is one of the risks merchant semiconductor makers must take if they are to survive.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.

APPENDIX

Table 1: U.S. Apparent Domestic Consumption of Semiconductors, 1982-86

(in thousands of dollars)

	1982	1983	1984	1985	1986
			(including parts)		
Total Shipments	$10,728,702	$12,481,288	$17,395,417	$13,631,929	n.a.
Total Exports (f.a.s.)	3,797,368	4,361,466	5,334,635	4,239,177	4,869,694
Total Imports (Customs)	4,127,661	4,934,479	7,594,872	5,672,209	5,967,420
Trade Balance	-330,293	-573,013	-2,260,237	-1,433,032	-1,097,726
Apparent Domestic Consumption	11,058,995	13,054,301	19,655,654	15,064,961	n.a.
Exports as Percent of Apparent Domestic Consumption	34.3%	33.4%	27.1%	28.1%	n.a.
Imports as Percent of Apparent Domestic Consumption	37.3%	37.8%	38.6%	37.7%	n.a.
Exports to Japan (f.a.s.)	190,360	260,946	363,917	236,706	294,329
Imports from Japan (Customs)	583,607	917,739	1,978,397	1,316,893	1,381,669
Trade Balance	-393,247	-656,793	-1,614,480	-1,080,187	-1,087,340
Exports to Japan as Percent of Apparent Domestic Consumption	1.7%	2.0%	1.9%	1.6%	n.a.
Imports from Japan as Percent of Apparent Domestic Consumption	5.3%	7.0%	10.1%	8.7%	n.a.
			(excluding parts)		
Total Shipments	8,994,616	10,652,364	15,653,076	12,097,769	n.a.
Total Exports (f.a.s.)	1,052,146	1,284,963	1,721,720	1,445,653	1,495,281
Total Imports (Customs)	3,895,147	4,521,789	6,698,332	4,865,536	5,088,993
Trade Balance	-2,843,001	-3,236,826	-4,976,612	-3,419,883	-3,593,712
Apparent Domestic Consumption	11,837,617	13,899,190	20,629,688	15,517,652	n.a.
Exports as Percent of Apparent Domestic Consumption	8.9%	9.2%	8.3%	9.3%	n.a.
Imports as Percent of Apparent Domestic Consumption	32.9%	32.5%	32.5%	31.4%	n.a.
Exports to Japan (f.a.s.)	153,389	216,727	277,972	148,960	168,876
Imports from Japan (Customs)	502,613	738,186	1,623,087	979,374	1,033,112
Trade Balance	-349,224	-521,459	-1,345,115	-830,414	-864,236
Exports to Japan as Percent of Apparent Domestic Consumption	1.3%	1.6%	1.3%	1.0%	n.a.
Imports from Japan as Percent of Apparent Domestic Consumption	4.2%	5.3%	7.9%	6.3%	n.a.

Source: Derived from following tables.

Table 2: Japan's Apparent Domestic Consumption of Semiconductors, 1982-86*

	1982	1983	1984	1985	1986
	(in millions of yen)				
Total Production	Y1,194,570	Y1,560,174	Y2,584,239	Y2,409,703	Y2,332,521
Total Exports (f.o.b.)	355,325	511,436	898,548	699,090	641,993
Total Imports (c.i.f.)	161,390	188,966	272,310	202,128	174,313
Trade Balance	193,935	322,470	626,238	496,962	467,680
Apparent Domestic Consumption	1,000,635	1,237,704	1,958,001	1,912,741	1,864,841
Exports as Percent of Apparent Domestic Consumption	35.5%	41.3%	45.9%	36.5%	34.4%
Imports as Percent of Apparent Domestic Consumption	16.1%	15.3%	13.9%	10.6%	9.4%
Exports to the United States (f.o.b.)	134,506	206,064	406,144	249,334	187,698
Imports from the United States (c.i.f.)	92,164	116,960	175,858	136,399	118,009
Trade Balance	42,342	89,104	230,286	112,935	69,689
Exports to the United States as Percent of Apparent Domestic Consumption	13.4%	16.6%	20.7%	13.0%	10.1%
Imports from the United States as Percent of Apparent Domestic Consumption	9.2%	9.4%	9.0%	7.1%	6.3%
	(in thousands of dollars)				
Total Production	$4,795,929	$6,568,877	$10,880,090	$10,101,882	$13,841,212
Total Exports (f.o.b.)	1,430,858	2,153,233	3,792,142	2,909,360	3,776,652
Total Imports (c.i.f.)	649,980	795,345	1,149,424	841,604	1,024,888
Trade Balance	780,878	1,357,888	2,642,718	2,067,756	2,751,764
Apparent Domestic Consumption	4,015,051	5,210,989	8,237,372	8,034,126	11,089,448
Exports to the United States (f.o.b.)	541,642	867,565	1,714,049	1,037,638	1,104,171
Imports from the United States (c.i.f.)	371,180	492,277	742,299	567,927	693,844
Trade Balance	170,462	375,288	971,750	469,711	410,327

*Neither Japan's production data nor its trade data include parts.

Source: Derived from following tables.

Table 3: U.S. Shipments of Semiconductors, 1982-85*

(value in thousands of dollars; quantity in thousands of units)

	1982	1983	1984	1985(p)
Value				
Integrated Circuits	$7,321,719	$8,903,267	$13,323,719**	$10,090,309**
Linear	764,254	n.a.	1,934,536	1,444,545
Digital Bipolar	2,143,762	2,789,044	4,332,792	3,335,654
Transistor-Transistor Logic	1,123,849	1,310,805	2,746,097	2,037,010
Other Logic]			901,519	657,689
Memory]	1,019,913	1,478,239	317,211	311,971
Other]			367,965	328,984
Digital MOS	3,559,212	4,895,818	5,069,500	3,885,650
Microprocessors	507,786]		1,053,290	830,468
Logic	1,091,567]	1,601,761	1,154,392	1,146,407
Memory	1,959,859	3,294,057	2,861,818	1,908,775
DRAMs	n.a.	n.a.	1,686,747	1,096,762
SRAMs	n.a.	n.a.	380,990	420,945
ROMs	n.a.	n.a.	129,537	87,803
EPROMs***	n.a.	n.a.	160,770	60,512
EEPROMs***	n.a.	n.a.	14,263	13,581
Other Monolithic	n.a.	406,646	572,381	126,516
Hybrid	854,491	811,759	1,050,513	1,193,386
Discrete Devices	1,672,897	1,749,097	2,329,357	2,007,460
Transistors	596,799	625,720	823,689	668,527
Diodes and Rectifiers	493,517	541,097	661,681	640,869
Other	582,581	582,280	843,987	698,064
Parts	1,734,086	1,828,924	1,742,341	1,534,160
Total Shipments	10,728,702	12,481,288	17,395,417	13,631,929

(continued)

Table 3: U.S. Shipments of Semiconductors, 1982-85* (continued)

(value in thousands of dollars; quantity in thousands of units)

	1982	1983	1984	1985(p)
Quantity				
Integrated Circuits	n.a.	n.a.	n.a.	n.a.
Linear	n.a.	n.a.	1,234,897	908,381
Digital Bipolar	n.a.	n.a.	7,095,066	5,179,875
Transistor-Transistor Logic	n.a.	n.a.	6,536,484	4,801,173
Other Logic	n.a.	n.a.	377,476	187,788
Memory	n.a.	n.a.	54,115	60,852
Other	n.a.	n.a.	126,991	130,062
Digital MOS	n.a.	n.a.	1,093,754	787,888
Microprocessors	n.a.	n.a.	130,558	90,874
Logic	n.a.	n.a.	427,159	384,577
Memory	n.a.	n.a.	536,037	312,437
DRAMs	n.a.	n.a.	271,705	168,597
SRAMs	n.a.	n.a.	47,457	75,096
ROMs	n.a.	n.a.	50,271	28,828
EPROMs***	n.a.	n.a.	13,502	4,921
EEPROMs***	n.a.	n.a.	2,021	1,351
Other Monolithic	n.a.	n.a.	n.a.	n.a.
Hybrid	n.a.	n.a.	n.a.	n.a.
Discrete Devices	n.a.	n.a.	n.a.	n.a.
Transistors	n.a.	n.a.	n.a.	n.a.
Diodes and Rectifiers	2,627,940	3,177,843	3,387,035	2,744,937
Other	n.a.	n.a.	n.a.	n.a.

*Data on 1986 shipments will not be available until late 1987.
**Totals include some products not broken out below.
***Figures do not represent complete product line since data on certain densities of devices are suppressed to avoid disclosing information on individual companies.

Source: U.S. Department of Commerce, Current Industrial Reports: Selected Electronic and Associated Products, Including Telephone and Telegraph Apparatus, 1983 and 1984 (MA-36N); Current Industrial Reports: Semiconductors, Printed Circuit Boards, and Other Electronic Components, 1985 (MA-36Q).

Table 4A: Total U.S. Exports of Semiconductors, 1982-86

(in thousands of dollars)

	1982	1983	1984	1985	1986
Integrated Circuits	$836,261	$1,025,723	$1,391,329	$1,140,636	$1,148,136
Linear	113,228	170,254	275,243	214,054	211,579
Digital Bipolar	133,320	144,668	223,733	177,036	202,724
Logic	97,501	105,786	158,711	136,616	162,869
Memory	35,819	38,882	65,022	40,420	39,855
Digital MOS	413,265	468,376	650,946	606,774	565,666
Microprocessors	91,749	102,382	159,983	101,697	178,570
Logic	131,571	177,963	213,201	219,629	264,019
Memory	189,945	188,031	277,762	205,448	123,077
RAMs	95,346	101,244	165,811	149,415	81,734
Other Monolithic	104,408	138,814	126,577	69,118	92,206
Hybrid	72,040	103,611	114,830	73,654	75,961
Discrete Devices	215,885	259,240	330,391	305,017	347,146
Transistors	81,764	97,897	118,844	123,147	138,760
Diodes and Rectifiers	74,244	89,846	111,710	94,044	108,652
Other	59,877	71,497	99,837	87,826	99,733
Parts	2,745,222	3,076,503	3,612,915	2,793,524	3,374,413
Total Exports	3,797,368	4,361,466	5,334,635	4,239,177	4,869,694

Table 4B: U.S. Exports of Semiconductors to Japan, 1982-86

(value in thousands of dollars; quantity in thousands of units)

	1982	1983	1984	1985	1986
Value					
Integrated Circuits	$142,669	$200,269	$253,707	$130,605	$144,567
Linear	18,081	44,873	81,771	33,574	28,571
Digital Bipolar	26,265	33,815	48,017	24,109	41,959
Logic	18,102	23,508	30,266	13,542	30,852
Memory	8,163	10,307	17,751	10,567	11,107
Digital MOS	75,208	86,839	101,207	60,438	56,149
Microprocessors	16,011	17,951	19,841	18,116	21,263
Logic	23,526	35,183	38,449	16,964	20,729
Memory	35,671	33,705	42,917	25,358	14,158
RAMs	7,139	10,211	19,604	16,785	9,360
Other Monolithic	4,035	5,777	6,868	3,092	7,972
Hybrid	19,080	28,965	15,844	9,392	9,916
Discrete Devices	13,720	16,458	24,265	18,355	24,309
Transistors	6,408	6,823	8,300	5,943	10,165
Diodes and Rectifiers	3,666	4,403	5,729	4,865	5,735
Other	3,646	5,232	10,236	7,547	8,410
Parts	33,971	44,219	85,945	87,746	125,453
Exports to Japan	190,360	260,946	363,917	236,706	294,329
Quantity					
Integrated Circuits	53,100	95,574	159,032	65,690	51,938
Linear	13,244	35,366	75,508	25,885	16,523
Digital Bipolar	13,663	22,708	24,691	12,034	13,520
Logic	9,846	17,945	19,610	7,722	10,507
Memory	3,817	4,763	5,081	4,311	3,013
Digital MOS	20,007	29,570	55,076	26,115	18,669
Microprocessors	3,181	4,861	4,398	3,653	3,780
Logic	9,886	15,595	30,437	11,021	9,233
Memory	6,940	9,115	20,241	11,441	5,656
RAMs	2,468	5,964	10,282	8,992	4,012
Other Monolithic	1,716	2,661	2,409	917	2,670
Hybrid	4,470	5,270	1,348	739	556
Discrete Devices	17,827	25,414	29,737	16,889	26,102
Transistors	7,454	10,990	9,944	6,545	15,403
Diodes and Rectifiers	8,826	12,540	17,245	7,692	8,386
Other	1,547	1,884	2,548	2,651	2,313

Source: U.S. Department of Commerce, U.S. Exports: Schedule E Commodity by Country (FT 410)

Table 5A: Total U.S. Imports of Semiconductors, 1982-86

(in thousands of dollars)

	1982	1983	1984	1985	1986
Integrated Circuits	$3,461,331	$4,075,104	$6,055,156	$4,364,897	$4,508,905
Linear	388,107	482,322	714,834	576,069	597,957
Digital Bipolar	846,904	1,082,397	1,546,691	973,340	1,127,775
Logic	614,683	813,661	1,216,802	754,366	828,203
Transistor-Transistor Logic	513,015	714,456	1,055,437	652,581	712,405
Memory	232,221	268,736	329,889	218,974	249,348
Digital MOS	2,084,522	2,367,695	3,619,199	2,598,305	2,415,840
Microprocessors	267,615	330,169	513,945	349,610	473,561
Logic	442,529	520,085	958,310	824,583	709,738
Memory	1,374,378	1,517,441	2,146,944	1,424,112	1,232,542
RAMs	834,359	1,036,820	1,605,180	947,084	773,376
8K, 16K and 32K	n.a.	486,402	451,102	310,665	226,306
64K	n.a.	510,933	944,841	405,845	173,698
256K	n.a.	39,124	198,748	200,942	353,880
1MB	n.a.	361	10,489	29,632	19,493
Other Monolithic	45,696	44,762	79,405	89,509	113,710
Hybrid	96,102	97,928	95,027	127,674	253,622
Discrete Devices	433,816	446,685	643,176	500,639	580,088
Transistors	259,661	248,137	331,393	242,669	278,657
Diodes and Rectifiers	112,479	129,469	212,150	181,700	215,270
Other	61,676	69,079	99,633	76,270	86,162
Parts	232,514	- 412,690	896,540	806,673	878,427
Total Imports	4,127,661	4,934,479	7,594,872	5,672,209	5,967,420

Table 5B: U.S. Imports of Semiconductors from Japan, 1982-86

(value in thousands of dollars; quantity in thousands of units)

	1982	1983	1984	1985	1986
Value					
Integrated Circuits	$444,967	$677,111	$1,520,346	$879,727	$926,840
Linear	22,397	31,168	51,333	45,348	47,824
Digital Bipolar	70,874	72,607	129,995	93,238	126,072
Logic	40,753	45,899	69,147	41,931	56,748
Transistor-Transistor Logic	7,915	23,918	33,393	15,686	26,626
Memory	30,121	26,708	60,848	51,307	69,324
Digital MOS	328,968	544,410	1,278,259	699,872	692,771
Microprocessors	9,279	29,356	93,137	70,126	85,350
Logic	34,036	67,795	207,017	152,257	169,217
Memory	285,653	447,259	978,105	477,489	438,204
RAMs	215,950	353,098	809,184	372,290	365,869
8K, 16K and 32K	n.a.	117,777	161,330	95,047	58,503
64K	n.a.	209,298	459,082	126,090	56,623
256K	n.a.	26,023	188,772	150,914	232,206
1MB	n.a.	0	0	239	18,537
Other Monolithic	1,516	2,722	23,717	13,511	5,225
Hybrid	21,212	26,204	37,042	27,758	54,948
Discrete Devices	57,646	61,075	102,741	99,647	106,272
Transistors	37,736	32,662	51,516	41,434	48,514
Diodes and Rectifiers	12,530	20,580	40,252	46,970	44,137
Other	7,380	7,833	10,973	11,243	13,620
Parts	80,994	179,553	355,310	337,519	348,557
Imports from Japan	583,607	917,739	1,978,397	1,316,893	1,381,669
Quantity					
Integrated Circuits	193,413	332,663	505,472	332,767	455,745
Linear	31,360	52,162	77,592	48,446	54,800
Digital Bipolar	33,276	68,302	77,805	45,557	79,271
Logic	27,890	63,701	69,533	37,053	70,154
Transistor-Transistor Logic	22,126	56,925	60,124	28,248	61,465
Memory	5,385	4,601	8,273	8,504	9,118
Digital MOS	116,157	191,581	310,515	201,643	294,581
Microprocessors	2,679	6,659	26,486	20,441	27,155
Logic	18,302	38,592	48,779	45,809	85,517
Memory	95,177	146,330	235,251	135,394	181,909
RAMs	68,410	114,525	195,379	106,926	157,183
8K, 16K and 32K	n.a.	51,587	56,132	32,451	33,071
64K	n.a.	61,723	128,133	41,328	27,100
256K	n.a.	1,215	11,114	33,132	95,710
1MB	n.a.	0	0	16	1,303
Other Monolithic	1,674	3,610	21,706	19,700	3,844
Hybrid	10,947	17,008	17,854	17,420	23,249
Discrete Devices	369,836	334,052	452,736	357,282	606,167
Transistors	144,136	91,962	80,609	81,211	194,418
Diodes and Rectifiers	209,083	233,245	359,292	265,649	400,408
Other	16,617	8,845	12,836	10,423	11,342

Source: U.S. Department of Commerce, U.S. Imports for Consumption and General Imports (FT 246)

Table 6: Japan's Production of Semiconductors, 1982-86

(value in millions of yen*; quantity in thousands of units)

	1982	1983	1984	1985	1986(p)
Value					
Integrated Circuits	Y834,883	Y1,139,523	Y1,973,850	Y1,841,790	Y1,780,101
Linear	176,332	222,279	331,419	350,333	338,166
For Industrial Equipment	41,777	45,082	68,541	70,588	83,229
For Consumer Goods	134,555	177,197	262,878	279,745	254,937
Digital Bipolar	130,493	153,371	261,004	256,076	273,390
Logic	104,232	130,805	223,726	214,827	230,052
Memory	26,261	22,566	37,278	41,249	43,337
Digital MOS	436,646	663,643	1,235,596	1,070,965	999,305
Logic	208,177	296,387	481,885	482,095	483,544
Memory	228,469	367,256	753,711	588,870	515,760
Hybrid	91,412	100,230	145,831	164,417	169,241
Discrete Devices	359,687	420,651	610,389	567,913	552,420
Transistors	143,457	152,726	224,845	206,205	196,041
Diodes and Rectifiers	102,129	122,004	170,763	142,752	139,900
Other	114,101	145,921	214,781	218,956	216,479
Total Production	1,194,570	1,560,174	2,584,239	2,409,703	2,332,521
Quantity					
Integrated Circuits	4,381	6,230	9,516	9,350	11,144
Linear	1,641	2,252	3,463	3,624	3,972
For Industrial Equipment	377	443	653	646	1,026
For Consumer Goods	1,264	1,810	2,809	2,978	2,946
Digital Bipolar	963	1,387	2,230	1,882	2,379
Logic	935	1,355	2,188	1,838	2,334
Memory	29	32	41	44	45
Digital MOS	1,559	2,311	3,486	3,485	4,364
Logic	1,021	1,571	2,334	2,358	2,889
Memory	537	741	1,152	1,127	1,475
Hybrid	219	279	338	360	428
Discrete Devices	21,555	28,077	42,406	38,283	43,087
Transistors	8,372	9,387	14,391	14,343	15,769
Diodes and Rectifiers	10,000	14,500	22,273	18,702	20,576
Other	3,183	4,191	5,743	5,237	6,743

*The following average annual exchange rates, calculated by the Ministry of Finance, can be used to convert the yen production figures into dollars: 1982, Y249.08; 1983, Y237.51; 1984, Y237.52; 1985, Y238.54; and 1986, Y168.52.

Source: Japan, Ministry of International Trade and Industry, Yearbook of Machinery Statistics

Table 7A: Japan's Total Exports of Semiconductors, 1982-86

(in millions of yen*)

	1982	1983	1984	1985	1986
Integrated Circuits	Y285,112	Y423,836	Y776,775	Y581,801	Y523,131
Packaged	223,670	345,467	669,891	486,169	436,030
Unpackaged	61,443	78,370	106,884	95,632	87,101
Discrete Devices	70,213	87,600	121,773	117,290	118,862
Packaged	59,305	74,041	103,288	100,747	101,516
Transistors	21,801	24,820	30,223	30,429	28,505
Diodes and Rectifiers	16,307	20,630	28,426	24,247	25,658
Other	21,197	28,591	44,638	46,071	47,354
Unpackaged	10,908	13,558	18,485	16,543	17,346
Total Exports	355,325	511,436	898,548	699,090	641,993

Table 7B: Japan's Exports of Semiconductors to the United States, 1982-86

(in millions of yen*)

	1982	1983	1984	1985	1986
Integrated Circuits	Y116,760	Y184,321	Y372,206	Y219,537	Y163,940
Packaged	109,893	170,630	349,946	207,244	154,737
Unpackaged	6,867	13,691	22,260	12,292	9,203
Discrete Devices	17,746	21,743	33,938	29,798	23,758
Packaged	16,919	20,661	32,167	27,692	21,869
Transistors	5,661	6,086	8,176	6,032	5,036
Diodes and Rectifiers	3,421	3,864	5,165	3,778	3,907
Other	7,838	10,711	18,826	17,882	12,926
Unpackaged	827	1,081	1,771	2,106	1,889
Exports to the United States	134,506	206,064	406,144	249,334	187,698

*The following average annual exchange rates, calculated by the Ministry of Finance, can be used to convert the yen export figures into dollars: 1982, Y248.33; 1983, Y237.52; 1984, Y236.95; 1985, Y240.29; and 1986, Y169.99.

Source: Japan Tariff Association, Japan Exports and Imports: Commodity by Country

Table 8A: Japan's Total Imports of Semiconductors, 1982-86

(in millions of yen*)

	1982	1983	1984	1985	1986
Integrated Circuits	Y127,382	Y152,602	Y222,176	Y165,439	Y146,075
Packaged	109,874	137,065	201,495	137,851	118,895
Digital	73,627	95,240	144,094	95,407	83,355
Other	36,248	41,825	57,402	42,444	35,540
Unpackaged	17,508	15,537	20,681	27,588	27,180
Discrete Devices	34,008	36,364	50,134	36,690	28,238
Packaged	33,864	36,006	48,739	34,983	27,598
Transistors	16,434	16,791	22,954	15,391	11,284
Diodes and Rectifiers	6,007	5,916	7,300	4,536	4,643
Other	11,424	13,298	18,485	15,056	11,671
Unpackaged	144	358	1,396	1,707	639
Total Imports	161,390	188,966	272,310	202,128	174,313

Table 8B: Japan's Imports of Semiconductors from the United States, 1982-86

(in millions of yen*)

	1982	1983	1984	1985	1986
Integrated Circuits	Y83,494	Y107,605	Y163,619	Y125,381	Y110,085
Packaged	71,349	95,608	145,631	102,160	88,179
Digital	55,696	73,155	113,195	78,536	68,503
Other	15,653	22,454	32,436	23,624	19,677
Unpackaged	12,145	11,996	17,989	23,222	21,906
Discrete Devices	8,670	9,355	12,238	11,018	7,924
Packaged	8,569	9,042	10,941	9,566	7,533
Transistors	2,102	1,951	2,320	2,173	1,985
Diodes and Rectifiers	1,397	1,614	1,821	1,742	1,445
Other	5,071	5,477	6,800	5,651	4,102
Unpackaged	101	313	1,298	1,452	391
Imports from the United States	92,164	116,960	175,858	136,399	118,009

*The following average annual exchange rates, calculated by the Ministry of Finance, can be used to convert the yen import figures into dollars: 1982, Y248.30; 1983, Y237.59; 1984, Y236.91; 1985, Y240.17; and 1986, Y170.08.

Source: Japan Tariff Association, Japan Exports and Imports: Commodity by Country